LETTERS TO THE EDITOR.

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Optical Glass: an Historical Note.

THE subject of optical glass is, at the present time, one of such paramount importance that no apology is needed for introducing it to the attention of your readers. As is well known, the Rev. Vernon Harcourt and Sir George Gabriel Stokes, in the earlier half of last century, laboured together for more than twenty-five years with the object of adding to our stock, new varieties of optical glass, but without success. Their labours, however, were afterwards continued by Prof. Abbe and Dr. Schott, of Jena, who, in the course of some five years, were completely successful. As the result of a critical examination of the work of the English workers, Dr. Czapski—then the head of the firm of Carl Zeiss, of Jena—came to the conclusion that Harcourt and Stokes had failed simply because they had not at their disposal the services of a sympathetic and competent glass-maker.

I have quite recently, by the courtesy of a friend, enjoyed the privilege of reading a number of letters, I believe as yet unpublished, written by Prof. Abbe, during the period of his work on optical glass, to a well-known English microscopist, now dead. One of these letters, dated October 9, 1881, is very interesting because it sets out very clearly the high-water mark in optical construction attained by optical glasses commercially obtainable before the Jena glasses were produced. The relevant part of this letter reads as follows:—

"The Crown and Flint which is applied now by Zeiss—for objectives, prisms, etc.—is within the limits of 1·5017 and 1·8017 refractive index for the D-line. The dispersion of the former is 0·00798, and of the latter 0·03287, measured for the interval between lines C and F. The density of the said Crown is approximately 2·40, and of the said heavy flint 5·1. The Crown above is not the ordinary Crown, which yields $n_D = 1{\cdot}515 - 1{\cdot}520$ and $n_F - n_C = 0{\cdot}00850 - 0{\cdot}00900$; it is a special glass of Feil (of Paris). The Flint named above—also from Feil—is not perfectly white, but the colour (yellowish) is not very perceptible in smaller pieces (lenses or prisms). It may be usefully applied for many purposes, though it leaves a rather great residual of secondary chromatism.

"Feil has made still more refractive Flint, approaching 1·9 in index. But this is strongly coloured and not fit for use in my opinion. The common Flint, which is applied for telescope-objectives, has N_D between 1·60 and 1·63, and $N_F - N_C$ between 0·0165 and 0·0180. The strongest Flint, which is made by Chance Brothers, of Birmingham (*i.e.* 'double-extra-dense' Flint), has $N_D = 1{\cdot}71 - 1{\cdot}72$ and $N_F - N_C$ between 0·0239 and 0·0241.

"All taken together, we have eighteen different kinds of Crown and Flint in constant use at Dr. Zeiss's workshop."

It is interesting to note that at the time referred to in the above letter Zeiss was entirely dependent upon Chance Brothers, of Birmingham, and Feil, of Paris, for his supplies of optical glass.

The research work commenced by Abbe and Schott in 1881 on a laboratory scale was so far successful that Prof. Abbe, writing in a second letter on February 21, 1883, says:—

"Regarding the glass experiments, of which I have told you a year ago, I may say, that they have had a very satisfactory progress, as well in regard to the purely scientific aims, for which the research had been undertaken, as in regard to the practical results which are obtained. We are now satisfied that the utilisation of these results for the fabrication of optical glass will be the basis of a good progress of practical optics in several respects. The question is now only how to introduce the results of the experimental research into the fabrication; for all that can be done in the laboratory is settled now, or nearly settled. For that other aim I have had already, during several months, long and troublesome negotiations in order to obtain for my fellow-labourer that assistance which could enable him to undertake the practical application of the long research. Even now, however, it is not yet settled that this will be possible—at least in the manner as it has been planned until now, and within a moderate time. But at all events, the quick utilisation of the research in favour of microscopic optics will not be questionable; we have obtained already, or will obtain within the next time, by mere laboratory operations, sufficient quantities of the new glasses, which are of interest for the microscope, for enabling Zeiss to begin with the practical application in this year (which notice, however, I request you to consider as a private one at present, because it would not be agreeable, to have this matter spoken of long before it is a matter of fact)."

This letter is very interesting, because it shows that at the time in question, so far as the comparatively small quantities of special glasses required for the production of microscope objectives was concerned, the laboratory output was sufficient to enable the work to be done. This fact at once points to the possibility of meeting the demand at the present time for very special glasses required in small quantities only, as, for example, the production of microscope objectives by laboratory rather than by factory methods.

The production of glass on a manufacturing scale was commenced at Jena in 1884, and was brought to a successful conclusion in 1886, when the first catalogue of the Jena glasses was issued.

The third letter written by Prof. Abbe is dated March 4, 1886, and was accompanied by one of the first—if not the first—homogeneous immersion apochromatic microscope objectives made. The letter reads as follows:—

"This is a homog. immersion of 1·40 apert. and 3·0 mm. focal-length, constructed by means of new kinds of optical glass which have been produced on the base of a systematical research into the optical qualities of the various elements admitting of vitrification. This research has been conducted through about three years in the way of laboratory work, chemical and optical, by myself and a fellow-labourer of the chemical and technical line (Dr. Schott) with the continuous assistance of two younger scholars, chemists and physicists; and has afterwards—nearly two years ago—induced the foundation—at Jena—of a technical establishment for the regular fabrication of all kinds of optical glass for general use. This glass-manufactory (which has been set up in 1884 by Dr. Schott, Messrs. Zeiss, and myself, with the aid of a subsidy of the Prussian Government) has taken up, and continued, the former experiments on the scale of fabricatory work, in order to make the results available for the various branches of practical optics. This is going on still—some tasks being settled (the production of the silicious glasses, which is in a regular fabrication since last summertime), other tasks being brought near to the aim. In the meanwhile, I have gone to work with theoretical research and computation; in order to find the proper formulas for the utilisation of the new

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kinds of glass in the construction of telescope objectives and microscope objectives.

"Regarding the latter aim, a series of objectives adjusted for the short continental tube is nearly finished; another series for your English microscopes —which requires different formulas—has been begun; and you and Mr. —— have at hand the first specimens of that series.

"The optical features of the new constructions, which are represented by this 1/8th of 1·4 ap., may be defined in that way; the various corrections are of a higher order than could be obtained formerly (or, more strictly spoken, the residuals of the various corrections, *i.e.* the defects of collection of the rays, are of a higher order according to mathematical terminology. (1) With the old kinds of crown and flint glass two different colours only could be collected to one focus, a secondary spectre remaining uncorrected. With the new glass those different colours unite at one point, a tertiary deviation being left only. (2) Formerly the spherical correction was confined to the rays of one colour; this correction being made for the middle part of the spectrum, the systems remained under-corrected, spherically, for the red rays, and over-corrected for the blue rays. Now the correction of sph. aberr. is obtained for two different rays of the spectrum at the same time, and the objective shows the same degree of chromatical correction for the central as for the marginal part of the aperture. (Of course, this higher degree of correction is not given by the glass from itself—it requires a very careful utilisation of the optical properties of the various kinds of glass at disposal, in order to fulfil all those conditions, and this was not even possible except by means of a greater complication of the constructions; I was obliged to introduce five separate lenses (for the aperture 1·4) instead of the four applied hitherto).

"The objective at hand is constructed on the single-front-type. It contains ten single lenses in five separate parts. Two only of these ten lenses contain silicious acid; the glasses of the other eight are phosphates and borates—the Crown and Flint glass which has been used by the opticians hitherto, does not contain, as essential constituents, more than six chemical elements, O, Si, K, Na, Ca, Pb; the lenses of the 1/8th contain, as essential components of the glass, not less than fourteen elements."

"I did not introduce a greater aperture than 1·40 in order to preserve a convenient working distance—which, in fact, is =0·25 mm.=1/100 in. The two oculars sent with the objective are constructed with the aim to compensate certain aberrations outside the axis, which cannot be got rid of in the objectives (of wide aperture). The whole series of objectives, high and low powers, shall be so arranged, that this compensation is always obtained by the same series of oculars."

This last letter, I think, will be acepted as setting out *inter alia* in a remarkably lucid way the optical advantages obtained by the introduction and employment of the Jena glass in optical constructions.

F. J. CHESHIRE.

Hamilton and the "Quantification of the Predicate."

IN NATURE for March 23, p. 78, in a review of De Morgan's "Budget of Paradoxes," re-issued by the Open Court Publishing Co., there is an allusion to Sir William Hamilton's "famous theory of the quantification of the predicate."

This theory was first set out by George Bentham, a nephew of Jeremy Bentham, in 1827, in his "Outlines of Logic," reviewed by Hamilton in the *Edinburgh Review* in 1833, and again raised by Mr. Warlow in the *Athenaeum* at the end of 1850, as may be read in the *Contemporary Review*, May, 1873, pp. 821–24.

Although Bentham never pushed his theory, it is clear that it came into Hamilton's mind from Bentham's book, and, as so often happens, the actual originator has been overlooked.

B. D. J.

THE ARCHÆOLOGICAL SURVEY OF NUBIA.[1]

IN the accounts of the preceding reports which have been published in NATURE attention has been directed to the exceptional thoroughness of the work, both of excavation and surveying, and the completeness of the presentment of the new information brought to light in this important archæological survey, which has been carried out by the Egyptian Survey Department.

In the present report Mr. Firth has fully maintained the high standard of excellence; and the complete and lucid statement of the facts, the liberal supply of text-figures, and especially the admirable collotypes, enable the reader almost to see and fully to understand the whole of the work, without the discomfort of living in a Nubian camp.

It is a matter for congratulation that this important and difficult investigation was carried out with such insight and thoroughness, for the flooding of the country makes it impossible ever to survey Lower Nubia again for archæological information. Without the knowledge so acquired the door would have been shut for ever upon a proper understanding of the early history of the Sudan, which is now being revealed by Prof. Reisner's excavations in the Kerma basin. Moreover, many of the difficulties in interpreting the story of Egypt would have been quite insurmountable without this information to make clear what was happening south of the First Cataract.

Most of the volume is devoted to the primary object of such a report, viz., the detailed and impartial statement of all the facts brought to light. It includes a brief account of the town site of Pselchis, and a full account of the mode of construction and contents of every grave.

The special importance of this report, however, depends upon the fact that it deals so largely with the remains of the distinctively Nubian culture, of which, from the circumstances of the case, it must represent for all time the chief source of information. In the introductory twenty-four pages Mr. Firth gives a well-balanced and illuminating survey of the early movements of people in the Nile valley, in which he clearly defines the position and the distinctive cultural relations of the Middle Nubian people (the "C-group"). The only criticism that I have to make of his account of this interesting people is the wholly unwarrantable suggestion of "the possibility that the C-group represents an immigration from the south-west of a mixed Negro and Libyan stock from

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[1] "The Archæological Survey of Nubia." Report for 1909–10. By C. M. Firth. (Cairo: Government Press, 1915.) Price L.E. 2.

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